Colorado Flower Growers Association, Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
Doris Fleischer, Executive Secretary,
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# Type of Greenhouse Covering May Affect CO2 Utilization by Carnations

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The effects of additional $CO_2$ to small greenhouses was greater on carnations under fiberglass than under glass. Grade of flowers showed a distinct improvement the third week after $CO_2$ additions were started in January. Where high $CO_2$ concentrations were maintained, yield of fancy grade flowers was 47% greater in the glass house and 90% greater in the fiberglass house. These comparisons are with a fiberglass house at the same temperature to which no $CO_2$ was added.

This preliminary test on the use of $CO_2$ from a Tectrol[a] generator was started at Colorado State University on January 19, 1964. One-year-old carnation plants of three varieties growing in three 15 X 18 ft. houses were used as the test plants. These plants had previously been used to evaluate Mylar film, glass and fiberglass coverings for greenhouses. The film, and fiberglass were replaced with new fiberglass in November prior to the start of this test in order to have two of the houses alike. The yield and grade of flowers from these plants for the 7 1/2 months preceding the $CO_2$ test were as follows:

| | Des. | Short | Stand. | Fancy | Total |
|---|---|---|---|---|---|
| House A | 148 | 380 | 1183 | 1144 | 2855 |
| House B | 176 | 582 | 1332 | 1052 | 3142 |
| House C | 199 | 594 | 1493 | 938 | 3224 |

Since there were no missing plants, it is assumed that differences were due to the type of covering on the greenhouse.

Due to unavoidable delay the Tectrol generator was not installed until January 19, two months after the new coverings were installed. $CO_2$ was added daily thereafter to the fiberglass house (A) and the glass house (B). No attempt was made to control $CO_2$ concentrations. The generator operated from 6:30 am to 5 pm until April 17, even when ventilation fans were on. Periodic measurements of the $CO_2$ concentration indicated nearly the same levels in the two houses. $CO_2$ concentration varied from a low around 400ppm when ventilation was on, to a high of about 1700ppm. Average $CO_2$ concentrations for random days during the period of treatment are shown in Table 1.

The houses were accurately controlled by thermostat and automatic fan and convection tube ventilation. Beginning in early November, all houses were heated to 54F at night and 65F during days. They were cooled by exhaust fans at 70F. These temperatures have been previously reported too high for carnations in Colorado during winter when $CO_2$ is not added. Since no $CO_2$ was added from

[a]The equipment used in this test was supplied by the Tectrol Division of Whirlpool Corporation, St. Joseph, Michigan. Measurements of $CO_2$ levels and gas analysis were done by Tectrol.

November to January 19, the average grade of flowers from all houses was low at the time the test was started.

Table 1. Average $CO_2$ concentrations, hours of fan ventilation and maximum outdoor temperatures for random dates during 1964.

| Date | House A $CO_2$ | House A Hours ventilated | House B $CO_2$ | House B Hours ventilated | House C $CO_2$ | House C Hours ventilated | Max. temperature |
|---|---|---|---|---|---|---|---|
| Jan. 24 | 1239 | 0 | 1250 | 0 | | | 30 |
| Jan. 28 | 1023 | 1 | 1176 | 1 1/4 | | | 60 |
| Jan. 29 | 1001 | 2 | 923 | 3 1/4 | | | 53 |
| Jan. 30 | 1012 | 3 | 893 | 3 1/2 | | | 52 |
| Feb. 18 | 872 | 0 | 854 | 0 | | | 37 |
| Feb. 19 | 874 | 0 | 868 | 0 | | | 43 |
| Feb. 20 | 934 | 2 | 860 | 2 1/2 | | | 40 |
| Feb. 21 | 787 | 0 | 762 | 0 | | | 40 |
| Mar. 10 | 919 | 0 | 870 | 0 | | | 39 |
| Mar. 17 | 556 | 7 1/2 | 438 | 8 1/2 | | | 65 |
| Mar. 30 | 494 | 8 1/4 | 429 | 8 1/2 | | | 65 |
| Mar. 31 | 628 | 8 | 614 | 8 1/2 | 348 | 8 | 74 |
| April 14 | 414 | 8 | 404 | 8 | 309 | 8 | 66 |
| April 16 | 457 | 9 | 434 | 9 1/4 | | | 78 |

All flowers of the White Pikes Peak variety cut after January 19 were weighed to the nearest gram. This series of weekly mean weights was found to correlate with the visual change in grade after $CO_2$ was added and shows the steady improvement in grade caused by $CO_2$ and by increasing light (Fig. 1). The improvement in weight of flowers in the untreated house could be assumed the normal recovery in grade of flowers following a winter when the carnations are grown at higher than optimum temperatures.

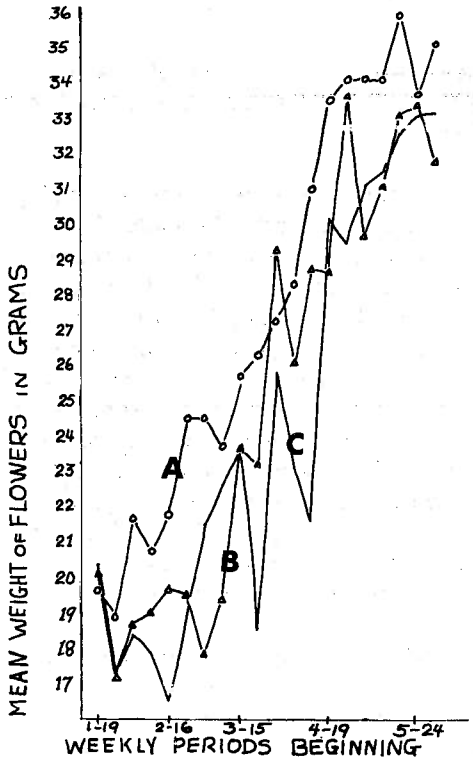


Fig. 1. The weekly mean weights of White Pikes Peak carnations receiving supplemental $CO_2$ compared to untreated plants.

Yield and grade records for two of the three varieties are shown in Table 2 for the period from February 2 to the end of the experiment. The third variety in these houses was required for stock plants midway in the test. While the mean grade is low for all houses, it was low before the experiment was started. The major response in a short term experiment such as this is in the grade of flowers produced. The total yield difference was a maximum of 8% between Houses B and C, however the yield of fancy grade flowers was 90% greater in House A and 47% greater in B, when compared to untreated House C.

Table 2. Yield and grade of carnations from three structures - February 2 to June 20, 1964.

| House and variety | Grade Des. | Short | Stand. | Fancy | Mean | Yield Total | Per $ft^2$ |
|---|---|---|---|---|---|---|---|
| House A - Fiberglass plus $CO_2$ | | | | | | | |
| White No. 86 | 48 | 85 | 210 | 163 | | 506 | 19.5 |
| White Pikes Peak | 40 | 75 | 232 | 370 | 4.30 | 717 | 27.6 |
| Total | 88 | 160 | 442 | 533 | | 1223 | 23.5 |
| House B - Glass plus $CO_2$ | | | | | | | |
| White No. 86 | 63 | 123 | 234 | 141 | | 561 | 21.6 |
| White Pikes Peak | 47 | 102 | 272 | 270 | 4.11 | 691 | 26.6 |
| Total | 110 | 225 | 497 | 411 | | 1252 | 24.1 |
| House C - Fiberglass | | | | | | | |
| White No. 86 | 49 | 244 | 263 | 62 | | 618 | 23.8 |
| White Pikes Peak | 31 | 58 | 230 | 218 | 4.18 | 537 | 20.7 |
| Total | 80 | 302 | 493 | 280 | | 1155 | 22.2 |

While there was a small difference in yield favored by Houses A and B, any great difference would not come until much later. New growths initiated in January and February would be expected to flower in August in Colorado. The small increases in yield in the $CO_2$ treated houses may have been caused by the stimulation of breaks already present when $CO_2$ was added.

During a part of this test plants sensitive to sulfur dioxide (lettuce), ethylene (tomato and African marigold), and smog (petunia) were grown in the three houses. No symptoms of toxic gas injury were developed on these plants nor were symptoms of sleepiness or shortened internodes developed on the carnations. An analysis of combusted gases taken from several sources on April 17 follows:

| Source | $CO_2$ | Methane | Ethane | Ethylene | Propane | Propylene |
|---|---|---|---|---|---|---|
| Tectrol Generator | 8% | .645ppm | .028ppm | .0085ppm | .145ppm | .0095ppm |
| House A | 8 | 2.85 | .0185 | .0105 | .0295 | .0095 |
| House B | 8 | 2.85 | .02 | .0105 | .0245 | .---- |
| Burner C | - | 41.0 | 2.3 | .068 | 8.45 | .0195 |

Burner C was producing near toxic amounts of ethylene and indicated less than perfect combustion. The effluent from the Tectrol burner sampled at the generator or in either of the houses was in a safe range for plants.

## Discussion

The mean concentrations of $CO_2$ maintained in two of the houses shown in Table 1 merit some additional comment. In general, the more ventilation required, the lower the concentrations maintained. At a 70F setting for fan operation, little or no ventilation was required when the outside maximum temperature was 40F or below. Since slightly less ventilation was required by the fiberglass

house, average $CO_2$ levels were usually a bit higher than in the glass house. While $CO_2$ concentration can be increased with full ventilation on (data from March 17 to April 16) the levels maintained are far lower than those earlier in the year when the system was closed.

The average $CO_2$ concentration for a given day can be extremely misleading. Figure 2 shows the average concentrations measured in the three houses on March 31. While the average for the day

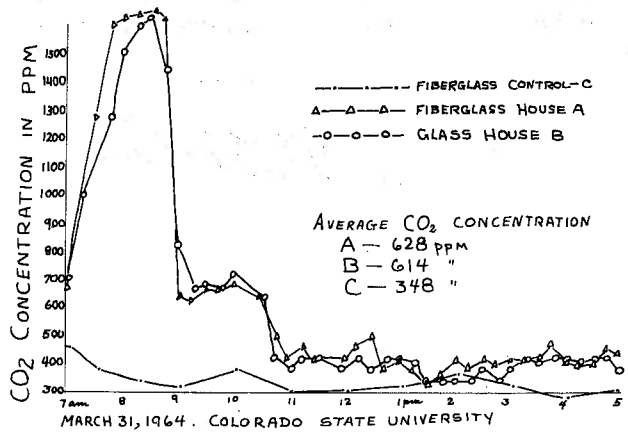


Fig. 2. The levels of $CO_2$ in two structures when no ventilation, medium and high rates of ventilation were used.

was reasonably high for Houses A and B, this average was unduely influenced by the extremely high levels before 9 am, when there was no ventilation. Fans began operating just before 9 am, air intakes were opened 18 inches from 9 to 10:30 and to 3 feet at 10:30. From 10:30 to 5 pm the $CO_2$ concentrations in the two treated houses were little more than 100ppm above that in the untreated house. The levels early in the day were probably too high for efficient use by carnations. Whether the increase obtained later in the day with high ventilation rates was sufficient to increase plant growth materially is doubtful. Under conditions of ventilation such as those on March 31, the efficient way to use $CO_2$ would probably be to cut off at 9 am, or no later than 10:30.

Some comparisons in this experiment are of doubtful validity. The two houses treated with $CO_2$ are comparable for the only difference between these was the type of covering material -- glass vs. fiberglass. A valid control for the experiment consists of an untreated check. The untreated fiberglass house was provided for a comparison with the treated fiberglass house. However to have only one factor ($CO_2$) in variance, higher than optimum temperatures had to be used in the untreated house. This causes comparisons between a $CO_2$ treated house and a control that was poorer than normal because of higher than optimum winter day temperature. In the future we may very well grow the control at the lower temperatures that have been found optimum in this climate without $CO_2$.